

Application of Data Envelopment Analysis in the Research of Tourism Resource Integration Efficiency

Yali Wu^{1,3}, Yajie Zhu¹ and Hans Mattingly²

¹School of Guangzhou College of Commerce, Guangzhou 511363, China

²School of The Affiliated High School of SCNU, Guangzhou 510000, China

³St .Paul University Philippines, Tuguegarao City, Cagayan 3500, Philippines

Abstract

This paper uses the data envelopment analysis method to extract relevant tourism resource integration elements for cluster integration, builds 31 models to analyze the results of calculations, analyzes the input and output of relevant elements of spatial artistic conception, and realizes the multiple synergistic advantages under the evolution of spatial artistic conception. The construction of the efficiency model of the integration of related resources and space. Using DEA and SPSS software, the linear regression model is used to report the predicted value, standardized predicted value, residual, and standardized residual. The mean value of the observed residual value is 0 through the test, which shows that the zero mean hypothesis of the regression model is satisfied. Based on the above data analysis, the regional differences and the law of change are obtained.

Keywords

Data Envelopment Analysis; DEA Model Classification Analysis; Computational Science.

1. Research Background and Significance

Following the guidelines of economic and trade cooperation, the tourism industry in the Guangdong-Hong Kong-Macao Greater Bay Area targets the most dynamic and advantageous goals. The three adjacent areas of Guangdong, Hong Kong, and Macao provide geographical advantages and economic advantages, coupled with distinctive attractions and a complete public foundation and service elements. Under the guidance of big data and smart tourism concepts, the evolution of tourism industry in the Greater Bay Area is also affected by the integration, transformation and modernization of industry. The opening of the Hong Kong-Zhuhai-Macao Bridge and the penetration of Qianhai's economy have increasingly expanded the areas of exchange and cooperation between Hong Kong and Macao. Study the artistic integration of rural tourism resources in the Guangdong-Hong Kong-Macao Greater Bay Area; cluster the artistic conception model and implementation path of the tourism area to realize the accelerated transformation and upgrading of the tourism economy; and promote the development of the tourism economy of the Guangdong-Hong Kong-Macao Greater Bay Area. In the open and shared tourism economy industry, study the integration of rural tourism resources and the spatial artistic conception to promote the development of the tourism economy under the new normal; "co-build a humanistic bay area"; "build a leisure bay area"; and "build a livable and travelable ecology circle"; are far-reaching directives [1] [2].

2. Overview of an Economy Integrating Rural Tourism in the Guangdong-Hong Kong-Macao Greater Bay Area.

Guangdong, Hong Kong, and Macau are adjacent to the Greater Bay Area, with Guangzhou, Shenzhen, and Zhuhai as the economic core of the Bay Area [3]. The author extensively studies the development of rural tourism in the Bay Area. Tracking and rural surveys are used to classify individual and integrated rural tourism resources in the two districts and nine cities, including 28 in Hong Kong, 18 in Macau, 76 in Zhuhai, 153 in Foshan, 479 in Huizhou, 9 in Dongguan. There are also 45 items in Jiangmen, 137 items in Zhaoqing, 151 items in Guangzhou, and 85 items in Zhongshan. Hong Kong and Macau are composed of natural tourism resources such as oceans, wetlands, mountains and hills, and cultural tourism resources that blend Chinese and Western cultures; nine cities, including Guangzhou, Foshan, and Shenzhen, are composed of natural rural landscapes, folk culture, settlement architecture, historical relics, industrial integration, and food. Composition of resources such as specialty products. Through precise positioning and the extension of main lines such as "HongKong-Shenzhen-Dongguan-Huizhou", "Guangzhou-Foshan-Zhaoqing", "Macao-Zhuhai-Zhongshan-Jiangmen", and so forth, The rural tourism artistic conception can be constructed.

The spatial artistic conception of rural tourism resources in the Guangdong-Hong Kong-Macao Greater Bay Area can be classified into basic types, sub-categories and main categories by sorting out the regional sources of rural tourism resources in the Bay Area. Extract the elements suitable for the integration of the spatial artistic conception of rural tourism in the Bay Area, and integrate the spatial artistic conception with the perspective of urban areas, township/village areas, scenic areas, scenic spots, and scenic sections. The main integrated expression methods and forms are:

- (1) "Hong Kong-Shenzhen-Dongguan-Huizhou": With complete transportation facilities, exquisite and comfortable rural circles, coupled with calm, noble cultural connotations and scarce ecological resources, the spatial artistic conception of its rural tourism resources is: sunset tidal flats, fishermen's scenery, rural settlement architecture, tranquility, and nature.
- (2) "Guangzhou-Foshan-Zhao qing": GuangFo is in the same city; sea and air infrastructure resources are integrated, and the spatial artistic conception of its rural tourism resources is: Lingnan ancestral hall, family sacrifices, Lingnan water town architecture, elegant and simple.
- (3) "Macao-Zhuhai-Zhongshan-Jiangmen": The Hong Kong-Zhuhai-Macao Bridge realizes the connection of transportation, tourism, and freight transportation, and promotes the rise of the central and western regions of the Pearl River. The spatial artistic conception of its rural tourism resources is: the integration of Chinese and Western cultures, migration culture, unity and cohesion, rich connotation, simplicity and tranquility.

3. DEA Research on the Integration of Spatial Artistic Conception

3.1. The Value of DEA Application

The value data envelopment analysis (DEA) and its application have been proposed by famous American operations researchers CHARNES and Cooper, etc. It is a method for comparing the relative efficiency and benefit of the Decision-Making Unit (DUM) [4].

3.2. Construction of Rural Tourism Economic Indicators in the Guangdong-Hong Kong-Macao Greater Bay Area

The Guangdong-Hong Kong-Macao Greater Bay Area is economically developed, following early development of the tourism economy; industry in the region has also matured, and many indicators are among the top in the country. Therefore, this study selects nine cities and two districts of the Guangdong-Hong Kong-Macao Greater Bay Area as the research object so as to

evaluate and analyze tourism efficiency and to test the effect of the spatial and artistic conception integration of tourism resources in the Bay Area.

This study adopts the DEA analysis method, whose function is to evaluate the relative validity between input and output data. From the perspective of the production function, the model is used to evaluate the efficiency of multiple input- and output-decision making units (Decision Making Unit, DMU). According to the realization of this model, the research on tourism efficiency is also effective. A single prefecture-level city is used as the decision-making unit (DMU) for tourism efficiency evaluation, and the distance between each DMU and the production frontier is determined to determine whether the DMU is DEA effective, so as to obtain the evaluation and ranking results. In view of the variability of the input of tourism industry elements, DEA calculation efficiency methods are divided into input, output and technology orientation. If the tourism efficiency of a city is higher, it means that among all the research objects, its output is the largest relative to the input. Research the Bay Area tourist accommodation facilities to receive overnight visitors, accommodation and catering industry (Hotels and Catering Services) revenue, total tourism revenue, tourism foreign exchange, passenger-kilometers, room occupancy rate, ecological environment index, air quality compliance, and statistics of daily and other evaluation indicators. The input indicators of the data model take assets, labor elements, and environmental elements as the main body, and the output indicators take income, profit, and the number of receptions as the main factors of efficiency evaluation (see Table 1)

Table 1. Analysis of input and output indicators of tourism economy in 2018

Indicators	Indicator type	Min	Max	Average	Standard deviation	variance
Input Indicators	Number of travel agencies	45	1521	329	426	447
	Number of employees	810	16096	6411	5376	5638
	Number of hotels	120	3189	948	792	830
	Number of rooms	29597	220136	74032	53123	55716
	Ecological Environment Index	61.9	98	74.27	12.08	12.67
	Air quality standard days	93.5	100	98.2	2.11	2.22
Output Indicators	Number of overnight tourists (10,000 people)	1371	6532	3413	1974	2071
	Total tourism revenue (100 million yuan)	294	4008	1295	1178	1235
	Room Occupancy Rate	49	91	67	13	13
	GDP(Billion yuan)	2914	22859	9880	8762	9190

3.3. Research Methods of Efficiency Measurement

Data envelopment analysis (DEA) is a nonparametric efficiency evaluation method. Its function is to evaluate the relationship between input and output data. From the perspective of production function, the model is used to evaluate the efficiency of a decision-making unit (DMU) with multiple inputs and outputs. According to the implementation of the model, the research on tourism efficiency is also effective. A single prefecture level city is regarded as the decision-making unit (DMU) of tourism efficiency evaluation, and the DEA effectiveness of a DMU is judged by determining the distance between the DMU and the production frontier, so as to obtain the evaluation and ranking results. In view of the controllable input of tourism industry elements, DEA calculation efficiency is divided into input, output, and technology orientation. If the tourism efficiency of a city is higher, the output of the DMU is larger relative to the input. Using DEA-Solver Pro5.0 software to establish the model, data envelopment analysis provides information on the efficiency value, simple descriptive statistics, relaxation

variable values, and other data important for the tourism industry, and provides a reference object for each decomposition unit for improving its efficiency value.

In this study, the DEA efficiency method is used to analyze the input and output of 9 cities and 2 districts for 2018, and finds that the efficiency of the tourism industry in Guangdong, Hong Kong and Macao Bay fluctuated slightly, but the overall level remained high. By calculating the average efficiency of tourism industry in each city, the study shows that there were six high efficiency areas, where the average efficiency value was greater than 0.9, which were Jiangmen, Huizhou, Macao, Zhaoqing, Zhongshan and Guangzhou. There were four average efficiency areas, where the average was between 0.60 and 0.89, which were Dongguan, Hong Kong, Foshan and Shenzhen. Finally, there was one low efficiency area, where the mean was less than 0.6, which was Zhuhai.

4. Construction of an Industrial Efficiency Model based on Spatial and Artistic Conception Integration

4.1. Descriptive Analysis of Economic Entities in the Bay Area

According to the main model of tourism economy, establish main lines such as "Hong Kong-Shenzhen-Dongguan-Huizhou Tourism Economy", or "Guangzhou-Foshan-Zhaoqing Tourism Economy", or "Macao-Zhuhai- Zhongshan-Jiangmen", "X+X+X+Tourism Economy", etc. This study assigns values of 3, 2, and 1 to cities with high efficiency, medium efficiency, and low efficiency, and provides a descriptive analysis of the economy (see Table 2).

Table 2. Descriptive model of industrial efficiency of artistic conception integration

Main economic model	HongKong-Shenzhen-Dongguan-Huizhou	Guangzhou-Foshan-Zhaoqing	Macao-Zhuhai-Zhongshan-Jiangmen
Efficiency value	Medium-medium-medium-high	High-medium-high	High-low-high-high
Assignment 1	2.00	3.00	3.00
Assignment 2	2.00	2.00	1.00
Assignment 3	2.00	3.00	3.00
Assignment 4	3.00		3.00
Assigned mean	2.25	2.67	2.50
Assigned std	0.43	0.47	0.87
Efficiency1	0.70	0.90	1.10
Efficiency2	0.70	0.70	0.60
Efficiency3	0.70	1.00	1.00
Efficiency4	1.10		1.50
Frequency mean	0.80	0.87	1.05
Efficiency standard deviation	0.17	0.12	0.32
Efficiency1	0.70	0.90	1.10

Research data statistics divide the efficiency of the Guangdong-Hong Kong-Macao Greater Bay Area into high-, medium- and low-efficiency areas, indicating:

First, high-efficiency areas: This area is based on Guangzhou, which has a higher overall economy, and other areas are located in the east, west and south wings of the Bay Area. In general, the six regions of the Guangdong-Hong Kong-Macao Greater Bay Area have higher tourism industry efficiency. For example, the efficiency of Jiangmen, Huizhou, Macau, Zhaoqing, Zhongshan, and Guangzhou all maintained above 0.90. In the sample period, the efficiency models of Jiangmen, Huizhou, and Macau basically maintained efficiency at greater than 1.0. Some efficiency models of Zhaoqing, Zhongshan and Guangzhou are equal to or lower than 0.7:

Zhaoqing has 7 values of low efficiency, Zhongshan has 13 values of low efficiency, and Guangzhou has 13 values of low efficiency. Therefore, the area needs to re-adjust the industrial configuration, including the reasonable allocation of various resource elements, the investment of tourism talents, and the investment of capital, so that the efficiency of the tourism industry can be maintained in the later period and the efficiency of the tourism industry can be stabilized. Second, the medium-efficiency region: This region is centered on Shenzhen, where the overall economic level is relatively high. Other regions are located in the east and west wings of the Bay Area. The average efficiency values of Dongguan, Hong Kong, Foshan and Shenzhen are between 0.69-0.73. Due to the exposure of scale efficiency and industrial structure problems in 2018, the tourism industry is showing signs of difficulty in improving. Therefore, the district needs to examine the threat factors in the industrial model, make good use of the industrial opportunities in the tourism market, and continuously improve industrial efficiency through government macro-control and rational resource allocation by enterprises, so as to avoid bottlenecks that reduce the efficiency of the tourism industry.

Third, low-efficiency areas: only Zhuhai has low-efficiency, with an efficiency value of 0.59, and its model values are basically low-efficiency. It can be seen that the allocation of tourism resources in this region is not reasonable, the industry lacks talents, and the ability to use technology is weak. Without improvement, the latter will continue to be weak.

In summary, the Guangdong-Hong Kong-Macao Greater Bay Area has Guangzhou, Shenzhen, Macau, and Hong Kong as the central cities. In the process of integrating tourism space and artistic conception, it is necessary to pay attention to complementary advantages, innovation and win-win situations, and the focus is on promoting the interconnection of tourism resource elements in each region. To develop the tourism industry system, the government has to improve the mechanism of guidance, and the market has to grasp the liquidity of various elements in a timely manner, giving full play to the leading role of Shenzhen-Hong Kong, Guangzhou-Foshan, Macau-Zhuhai, and has to fully drive the east and west wing tourism in the Bay Area. The development level of the industry will jointly improve the level of integrated construction of the tourism industry through the mutually beneficial and interactive interconnection of the various node cities in the Bay Area.

4.2. The Evolution of the Efficiency of Economic Entities in the Bay Area

According to the industrial efficiency evaluation of the nine districts and two cities in the Guangdong-Hong Kong-Macao Greater Bay Area, the evolution of the efficiency model can be classified as: first, continuous and efficient (see Figure 1).

The performance of cities belonging to this type of efficiency evolution is as follows:

First, the economic center, the extreme points of the Guangdong-Hong Kong-Macao Greater Bay Area, such as Guangzhou and Macau, which have a strong economic foundation, mature tourism development, and reasonable allocation of urban resource elements; second, underdeveloped cities, such as Huizhou, Zhongshan, and Jiangmen have good overall economic strength, but with the help of reasonable allocation of resource elements and the overall thrust of the Guangdong-Hong Kong-Macao Greater Bay Area, they still achieve high tourism industry efficiency.

Second, the volatility-effect type district should be considered (see Figure 2). The performance of cities belonging to this type of efficiency evolution is as follows: First, it is not only the center and extreme points of the Guangdong-Hong Kong-Macao Greater Bay Area, but also a developed industrial city, with a strong economic foundation, a more mature tourism development, and a more systematic and scientific allocation of urban resource elements; The overall economic strength of the area does not match the strength of its tourism industry, and the economic input of various industries is not balanced, which leads to a sharp increase or a sharp drop in the efficiency model of the tourism industry. The region should readjust its industrial layout, adjust

the input allocation of tourism industry elements, and strengthen internal strength through regional cooperation.

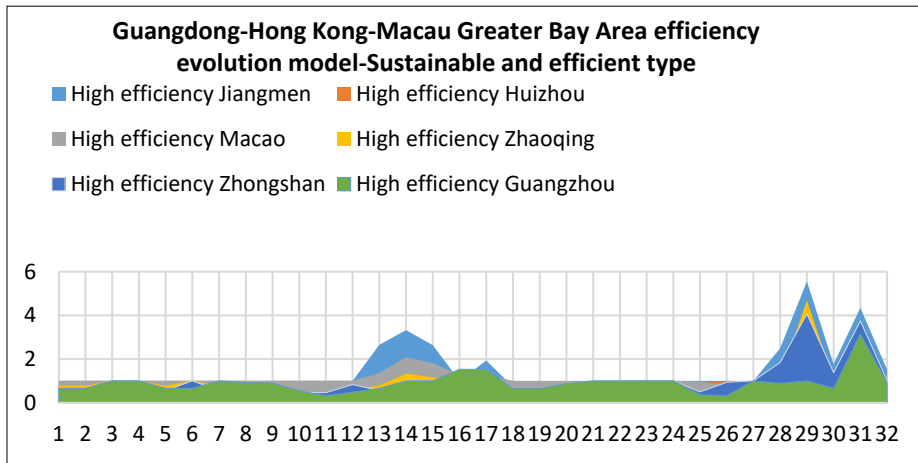


Figure 1. Guangdong-Hong Kong-Macao Greater Bay Area efficiency evolution model-Sustainable and efficient type

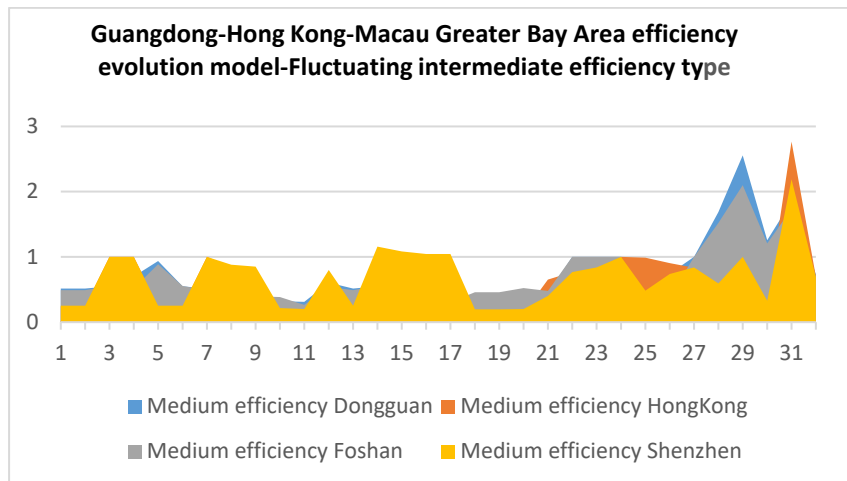


Figure 2. Guangdong-Hong Kong-Macao Greater Bay Area efficiency evolution model-Fluctuating intermediate efficiency type

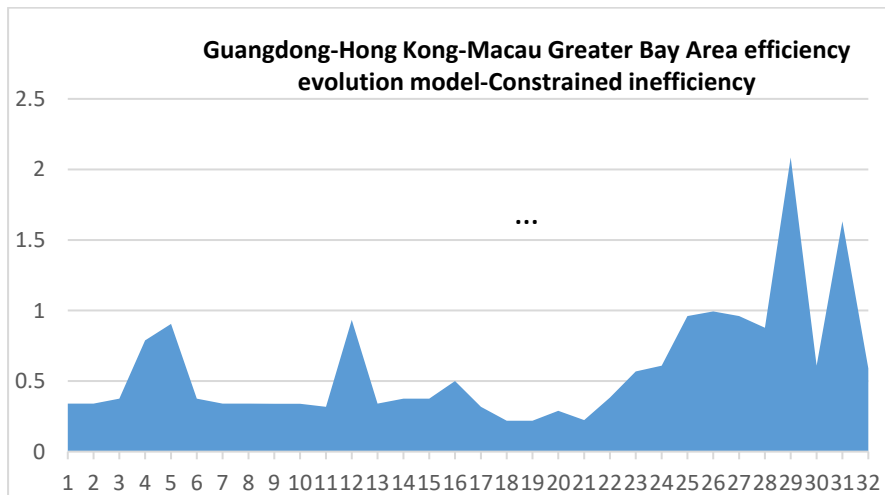


Figure 3. Guangdong-Hong Kong-Macao Greater Bay Area efficiency evolution model-Constrained inefficiency

Third, restrict inefficient types (see Figure 3). The performance of cities belonging to this type is as follows: First, the overall economic strength is better, but the investment in talents and tourism resources is less; Second, the importance of the local tourism industry needs to be improved. By improving the efficiency of technology utilization and scale investment, the establishment of the economic orientation is expected to better improve the efficiency of the tourism industry in these areas.

4.3. Linear Correlation Analysis

Table 3. Descriptive model

Principal Economic Model	Hongkong-Shenzhen-Dongguan-Huizhou	Guangzhou-Foshan-Zhaoqing	Macao-Zhuhai-Zhongshan-Jiangmen
Efficiency value	M-M-M-H	H-M-H	H-I-H-H
Assignment 1	2.00	3.00	3.00
Assignment 2	2.00	2.00	1.00
Assignment 3	2.00	3.00	3.00
Assignment 4	3.00		3.00
Assignment average	2.25	2.67	2.50
Assignment Standard Deviation	0.43	0.47	0.87
Efficiency 1 1	0.70	0.90	1.10
Efficiency 1 2	0.70	0.70	0.60
Efficiency 1 3	0.70	1.00	1.00
Efficiency 1 4	1.10		1.50
Frequency mean	0.80	0.87	1.05
Standard deviation of efficiency	0.17	0.12	0.32

It can be seen that the Pearson correlation coefficient between the mean of the efficiency value and the assigned mean of each region is 1, and the significance level is <0.05 , indicating that the two variables are highly correlated positively, and the correlation between the two variables in the overall relationship is also significant.

4.4. Unary Linear Regression Analysis

Through the establishment of a linear regression model, the predicted value, standardized predicted value, residual, and standardized residual were reported. The test shows that the mean value of the observed residual value is 0, which shows that the regression model meets the assumption of zero mean.

To sum up, through the analysis of the measurement results of 31 model construction of the industrial efficiency of the spatial and artistic conception integration of rural tourism resources in the Guangdong-Hong Kong-Macao Greater Bay Area, and through the relevance and first-line regression of the descriptive model construction, we pay attention to the analysis of the input and output of the spatial and artistic tourism elements. The analysis of spatial artistic conception government and environmental driving mechanism, the layout and evolution of spatial artistic conception, and the multiple synergistic advantages under the evolution of spatial artistic conception, so as to realize the construction of an industrial efficiency model of rural tourism resources and artistic conception integration.

5. Conclusion

This article contains research on the industrial efficiency of the spatial artistic conception of tourism resources in the Guangdong-Hong Kong-Macao Greater Bay Area, and showed that the construction of the spatial artistic conception needs to follow core-led policy linkage,

diversified investment to create system construction, and precise positioning and integration of spatial artistic conception. Cultivating cultural traditions, promoting cultural exchanges, and building a diversified construction pattern can drive cultural attraction and industrial upgrading in the Guangdong-Hong Kong-Macao Greater Bay Area.

Acknowledgments

Youth Fund for Humanities and Social Sciences Research of the Ministry of Education (NO. 20YJC790070).

The 14th five-year plan of philosophy and social science development in Guangzhou (NO. 2021GZGJ70).

School level project of Guangzhou Business School (NO. 2020XJDXSSJJD01, NO. 2020XJJG02).

Open Research Project of Guangdong-Hong Kong-Macao Greater Bay Area E-Commerce Research Center.

References

- [1] Guo Laixi, Wu Bihu et al: Classification system and type evaluation of China's tourism resources, *Acta Geographica Sinica*, Vol.3(2000) No.3, p.294-301.
- [2] Wang Yonghong: New changes in international economic and trade patterns from the perspective of global value chain theory--Take the "Belt and Road" cooperation area as an example, *Business Economics Research*, Vol.22(2019) No.11, p.162-165.
- [3] Wang Yaobin, sun Chuanling, Jiang Jinping: An Empirical Study on the efficiency of cultural tourism based on Three-stage DEA model: a case study of Gansu Province, *Tourism resources*, Vol.32(2016) No.1, p.125-128.
- [4] Wang enxu, Wu Di, Kuang Haibo: Comparative study on competitiveness and efficiency difference evaluation of tourism airports based on standard deviation-g1-dea, *Scientific research management*, Vol.37(2016) No.2, p.152-160.